Fluctuation and Noise Letters

Introduction to the UPoN-2018 Special Issue of *FNL*

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Noise is universal and multi-faceted. In everyday life, the aspects we encounter tend to be annoying, for example, loud conversations when we wish to enjoy a quiet cup of tea, or students chatting during a lecture. But acoustic noise can sometimes be useful e.g. when it indicates that the kettle is boiling, as an essential prelude to the tea, or when it helps to awaken somnolent students at the end of the lecture thereby eliminating the mutual embarrassment of needing to awaken them.

Similarly in science, noise as random fluctuations appears in different guises with a great diversity of origins. However, there is one feature in common to all manifestations of noise: it appears as the outcome of interactions between a huge number of components, such as charges in electronic devices, or atoms and molecules in proteins, or oscillators in an ensemble, or in an urban environment arising from the daily activities of people. This common feature defines the main challenges in the characterization and understanding of noise. Consequently, the open unsolved problems of noise are of wide applicability and naturally attract the attention of researchers from many different fields including some of the brightest and best from every generation of scientists.

The recent *8th International Conference on Unsolved Problems of Noise* (UPoN–2018), which was organised by Janusz Smulko at the Gdańsk University of Technology, Poland, during 9–13 July 2018, provided a platform for the research community to formulate, discuss and suggest ways tackling the unsolved problems of noise. The meeting was dedicated to Michael F. Shlesinger to celebrate his 70$^{\rm th}$ birthday, and in acknowledgement of his huge contributions to the subject area over the years, both scientifically and through his prescient provision of ONR funding to support research projects in stochastic nonlinear dynamics in the era before the potential

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technological importance of the subject was generally appreciated.

The UPoN conferences were initiated by Laszlo Kish, founder and Honorary Editor of *Fluctuation and Noise Letters*. The first UPoN meeting was in Szeged, Hungary, in 1996. Since then, there have been successor UPoNs in Adelaide (1999), Bethesda (2002), Gallipoli (2005), Lyon (2008), Kolkata (2012) and Barcelona (2015), leading up to UPoN–2018 in Gdańsk. In common with previous UPoNs, the meeting in Gdańsk included talks, presentations and discussions covering a large variety of noise topics. Following the UPoN tradition, the talks and discussions were often provocative, controversial, and very stimulating. This Special Issue brings together a representative selection of the topics discussed (except for those on noise in metrology, which are being published in *Metrology and Measurement Systems*).

A number of papers are devoted to noise in electronic devices. Methods for noise characterization are presented by Lentka and Smulko [1] and Ciofi *et al* [2]. Such methods are key to the comprehensive description of the stochastic output of devices. Experimental features of noise in electron transport in manganite single crystals are discussed by Przybytek and Jung [3], raising many open questions in search of theoretical explanations. Tretjak *et al* [4] have performed a comprehensive study of the noise properties of hybrid polymer composites, which are important components in modern bioelectronic devices. These composites include multi-walled carbon nanotubes and onion-like carbon particles, the presence of which defines strong temperature dependences in resistivity noise and provides an opportunity to control the noise characteristics. Experimental manifestations together with contemporary theoretical understanding of macroscopic telegraph noise in strongly correlated mesoscopic systems are discussed by Jung [5]: they describe superconductors and low Ca-doped manganites with colossal magnetoresistive as examples of systems that exhibiting similar macroscopic noise, but whose underlying noise-generating mechanisms are profoundly different.

Application of stochastic descriptions to complex deterministic systems are presented in the papers of Goldobin [6] and Dubkov *et al* [7]. In the former case, cumulant analysis – one of the basic tools in the description of noise – is applied to characterize phase dynamics. This approach allows the author to develop the theoretical framework for a deep characterization of the complex phenomena observed in a large ensemble of coupled oscillators. The latter paper presents a stochastic description of low-dimensional chaotic dynamics. The authors conclude that billiard-like particles interacting with harmonically oscillating boundaries can be considered as particles moving under the influence of white Gaussian noise whose intensity depends on the velocity of the boundary oscillations and the mean free path of the particles. This claim is supported by the results of numerical simulations.

Several papers tackle noise in biological problems. Shinagawa and Sasaki [8] provide a theoretical description of torque-enhanced diffusion in molecular motors in the presence of noise. The results of numerical calculations by the authors suggest a novel way of extracting certain properties of F_1-ATPase from the enhanced diffusion. Cugliandolo *et al* [9] consider the molecular motor as an example of an active Brownian particle, and present an approach for extracting an effective temperature based on deviations from the fluctuation dissipation theorem, illustrating the method through simulations of Langevin equations. Siódmiak and Bełdowski [10] study noise spectra in hydrogen bonding energy for different temporal scales, thereby illustrating the role of phospholipids in synovial fluid. The spectra showed power-law-scaling with a large sensitivity to the presence of phospholipids that can be used for the characterisation of the chemical content of synovial fluid. Barabash *et al* [11] discuss a theoretical framework for describing the experimentally measured currents in narrow biological ion channels. Validated by molecular dynamics and Brownian dynamics simulations, it is based on a quasiparticle representation of multi-ion interactions and thus provides a direct link to approaches widely used in condensed matter physics. A non-equilibrium and self-consistent multi-species kinetic model presented by Gibby *et al* [12] aims to describe the anomalous mole fraction effect which is observed in ion channels under varying concentrations of two different ionic species. The model developed explains very well the current in a single NaChBac sodium channel and is able to describe the influence of concentration difference in sodium and potassium ions on measured currents. Vadai *et al* [13] apply spectral analysis of $1/f$-type noise to characterize scaling laws in human mobility. Atypically, a $1/f$ scaling is observed for the high frequency part of the spectrum, opening up the challenging task of developing a theoretical description of this unusual scaling.

We hope that readers will enjoy perusing this Special Issue, which we believe conveys some flavour of the remarkable diversity of unsolved, and partly-solved, topical noise problems tackled during UPoN-2018.

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